Preliminary Investigations into a Possible Protocol for Avian Monitoring at the Phase 2 Restoration Site, Nisqually National Wildlife Refuge

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Abstract. The conversion of estuary wetland habitat to farmland has led to a decrease in biodiversity. As wetlands disappear around the world, many estuaries are now being managed for conservation rather than food production. In some cases, land managers have physically altered estuaries in an attempt to restore them to their original state. Bird species are key indicators of ecosystem status and have been used to assess the efficacy of restoration projects. To lay the groundwork for a long-term avian monitoring at an estuary restoration site on the south Puget Sound, we conducted a two-part investigation over the course of ten weeks in 2008. The first stage consisted of reconnaissance and lasted six weeks. During that time, we made frequent visits to the site and recorded observations on the layout and bird community. Once a protocol was chosen, we moved into the second stage. During that time, we conducted a trial run of the protocol. We employed a fixed-radius point-count method to collect data at random locations within the focal area, which we used to assess species richness, abundance, diversity, and frequency at the site. Fifty-four species were encountered during the first phase of the project, and a subset of 19 species was encountered during the second phase. Species richness, abundance, and diversity were variable across space and time. Species richness was higher in the eastern half of the focal area than in the western half but had no statistical relationship with tide level or time of day. There was no statistical relationship between abundance or diversity and tide level, time of day, or point location. Species occurrence frequency was also highly variable, with no clear trends. Our data set is rather small, but it indicates that, with a few modifications, this protocol might serve as a foundation for future monitoring.

Humans are attracted to estuaries by their plentiful resources (Nichols et al.1987), and many have settled there and established farms. Farmers control the water level by installing dikes and ditches. As an estuary's moisture level drops, changes occur in the chemical and physical conditions, and this has a strong impact on wetland-dependant organisms (**citation**). U.S. wetlands, both estuarine and palustrine, are in serious decline. Over the course of a decade—from the mid-1970's to the mid-1980's—the United States experienced a 2.6 million net loss of wetlands (Dahl et al 1991).

Wetlands provide habitat for a wide variety of plant and animal species, and they provide wintering grounds, nesting areas, and stopover sites for migratory birds (Dahl et al 1991). Many wetland-dependant species are federally listed as endangered or threatened. Habitat loss has slowed somewhat as some farms have been converted to wildlife refuges (**citation**). With the goal of conservation, many land managers are now looking for ways to restore estuaries to their original state.

One large restoration projects is taking place at the Nisqually River estuary on the southern end of the Puget Sound in Washington State. Once a patchwork of farms, the estuary gained federal protection in 1974, when it became the Nisqually National Wildlife Refuge under the United States Fish and Wildlife Service. The purpose of the refuge is to provide habitat for migratory birds, and the USFWS has accomplished this through both passive and active restoration efforts. The refuge straddles the Nisqually River, with the majority lying to the west.

The small parcel east of the river formerly belonged to Ken Braget, who used the land as a farm and pasture until he sold it to the Nisqually Indian Tribe in 1999 (Dodge, 2008). In 2002, the tribe carried out the first phase of a two-part restoration project that was aimed at improving salmon habitat. They removed dikes and filled borrow ditches. This would allow for tidal inundation, which they hoped would set the stage for a rebound in fish, invertebrate, and avian populations. In order to determine the success of their project, the tribe enlisted the Nisqually Reach Nature Center—a nonprofit corporation focusing on environmental education—to conduct an avian monitoring project. Many bird species depend on wetlands, and their abundance and distribution are key indicators of wetland health (Conway 2006).

Avian monitoring at the phase one site began in July, 2003 and continued for three years. With the help of volunteers, the Nisqually Reach Nature Center made frequent visits to the site (46 total) to conduct unlimited-radius transect surveys and point counts. They observed a significant increase in springtime species richness at the site, which indicated a higher visitation rate by migrating birds.

In 2006, the tribe carried out the second phase of the restoration project, at a 100-acre site south of the phase one area and north of interstate five. This site had been reclaimed for pasture. The tribe removed approximately 9500 feet of dike and filled 14,100 feet of ditches, which allowed tides to access the site. The remnants of historic tidal sloughs were reconnected with existing Red Salmon Slough and channels were dug to connect any remaining areas of water (WDFW, 2006). The site includes an upland riparian area of approximately 24 acres. The area was planted with 19,000 trees of at least 7 different native species (Dodge, 2008).

In 2008, the NRNC began organizing a second avian monitoring project, this time to assess the bird community at the phase two site. We joined the project to help design the protocol for the project. Over the course of ten weeks (March-June 2008), we conducted a two-part investigation. During the first segment of the investigation, which lasted six weeks, we made frequent visits to the site to familiarize ourselves with the area. We took notes on the physical characteristics of the site and birds observed there. In addition, we read up on a variety of options for protocol. During the second segment, we conducted a trial run of what we considered to be the best protocol, and we compiled and analyzed the data that we had gathered.

In our short study, we assessed the species richness, abundance, and diversity of birds within a focal area at the phase two restoration site. We examined the variability of these data and analyzed them to see whether there were any trends across space or time.

METHODS

Study Site—We identified the area north of the existing gravel road as the focal area. The restoration area contains three different habitat types; a newly planted upland riparian zone, a palustrine marsh area, and the study area, a tidally influenced mosaic of marsh and mud flat. This tidally influenced area was chosen as the focal area because this area was most altered by the restoration process. Focusing the study in this area alone limits the variability that arises when more than one habitat type is monitored. During the entire process, a complete species list was compiled (Table 1). This list represents all the bird species identified during the course of the study whether they were sighted in the study plots or not.

Despite eliminating vastly different habitat types, there was still variability across the focal area. All but one of the trees in the area had been felled, and some had been left behind to provide habitat, but they are not evenly distributed. The eastern half of the focal area is characterized by wet, often saturated mud, with a patchwork of tall sedge and bare mud. The western half of the study area is characterized by drier, spongy mud, with patches of shorter grass and other plants. At high tide, the eastern half becomes progressively inundated from the north; on the western half, certain depressions fill up before the rest is inundated. At the highest tides (>4.0 m), the entire site is inundated; at lower high tides, only the eastern half and certain depressions on the western half are inundated.

The phase two restoration area is located southeast of the mouth of the Nisqually River, with the river curving along its western edge. The river is separated from the restoration area by a north-south dike, but two east-west dikes—one along the northern boundary of the study site and one approximately 140 m south of it—were removed as part of the restoration process. Within the phase two area, there are several deep sloughs, which are overtopped only at the highest tides (>3.7 m). During the study, the highest and lowest tides ranged from 2.7 m to 4.1 m.

A slightly elevated gravel road runs from the entrance to the Nisqually River. For the first 230 meters, it runs northeast-southwest, parallel to interstate five and <30m from it. The gravel road then turns sharply away from the interstate and runs east-west for ~845m. A lesser dirt road runs from the western end of the gravel road north to the site boundary.

Decision-making Process—The population, area, and time frame of interest (Thompson 2002) were defined as being the entire bird community within the focal area during the migration and breeding season two years after a major restoration project. To better define the boundaries of our focal area, we chose the bend in the gravel road (N47º4’39”, W122º41’40”) as our southeastern corner and the end of the gravel road (N47º4'38.82", W122º42'19.62") as our southwestern corner, resulting in dimensions of approximately 811 m by 338 m.

We considered conducting counts along the road, but we decided instead to conduct them at random locations within the focal area, to ensure a non-zero probability of observing birds in any given location (Thompson 2002). A census would have been the preferable method, because it has proven effective in many cases (Burger et al. 1977, Hands et al. 1991, Recher 1966), but it was not feasible given the size and physical complexity of the focal area. We had then to choose between transect and point-count survey methods. In certain habitats, fixed-width transects and fixed-radius point counts have been shown to yield similar results (Dobkin & Rich 1998). After exploring the focal area, we decided to use the point-count method, because the transect method is only feasible in places where it is easy to walk.

Some studies have used limited-radius counts while others have used unlimited radius counts. Lynch (1995) found that unlimited-radius counts yield significantly more species than limited-radius counts but that the effect is not equal across species.

The objective when choosing a radius is to make it as large as possible while making sure that most of the individuals within it are visible (Hutto et al. 1986). On April 5th and 19th, Avian Monitoring, a Master of Environmental Science elective from The Evergreen State College, visited the study site and conducted point counts using the variable circular-plot method (Reynolds et al. 1980). Based on the data they collected, we identified the inflection point as 100 m and decided to use that distance as our radius for fixed-radius point counts.

Count period length is a compromise between seeing most species and collecting enough data points (Hutto et al 1986). We chose four consecutive repetitions of 15 minute surveys at each sample point, because initial observations suggested that one visit per point would not capture variability there. Repetitions serve effectively as repeat visits, offering the observer a better snap shot of the variability of the site.

Ideally, we would have conducted at least 25 point counts (Hutto et al. 1986). This could have been achieved by conducting more counts per day (Hutto et al.1986, Lynch 1995) or by having a longer survey period. However, time constraints prevented this, and we considered it worthwhile to conduct the experiment as a pilot study to provide estimates for future surveyors (Thompson 2002).

We decided against using any aids such as flushing lines and aural stimuli. Flushing lines were a popular method in the past, but studies have shown that they are labor intensive and don't yield good results (Dobkin and Rich 1998). Aural stimuli are appropriate in some cases, but while they increase species richness they have a greater impact on residents than migrants (Lynch 1995).

Ultimate Choice—Fixed-radius point counts were conducted at random locations within the area of interest. To select plot locations, Microsoft Excel was used to generate a list of coordinates. Each coordinate was comprised of a distance west and north from the origin—the southeastern corner of the area of interest—starting and ending within 100 m of the boundary. Google Earth was used to locate each point on the map and to record the latitude and longitude of the point. The latitude and longitude of the boundary in each cardinal direction were also recorded.

The study site was accessed as often as possible from 19 May 2008 until June 7, 2008. The observation time was one hour for each plot on each visit. The observers arrived 2 hours before high tide on each visit to the site. A Garmin GPS unit was used to locate the center of each fixed-radius plot. The radius of each plot was 100 meters, to ensure statistical independence (Hutto et al. 1986). Each plot was located 300 meters from the other. The perimeter of each plot was located with the GPS unit and marked with six foot bamboo poles with flagging tied to the top.

Four consecutive counts of 15 minutes each, for a total of 1 hour, were conducted on each plot, with the last count ending at high tide. At the beginning of the survey period, precipitation, cloud cover, and wind level were noted. During each count, bird species, number of individuals of each species, behavior, and substrate occupied were recorded.

Specifying whether birds were actively using the plot or flying over it was also noted. Aerial foragers—such as swallows—and hunters—such as hawks—were considered to be actively using the plot. Birds passing through the plot en route to another destination were not considered to be using the plot, and they were not included in statistical analysis.

There were two observers. Each point was manned by one observer. One to two points were established per day depending on availability of observers.

RESULTS

During the study, the highest and lowest tides ranged from 2.7 to 4.1 m. As with many other studies (Dobkin and Rich 1998), many of our observations were by sound.

Species Richness— Over the course of the entire investigation, we detected 54 bird species. We observed a subset of 19 species (35.2%) during the survey period. There was a high degree of variability among data points. The species richness varied from four to 12, with an average value of seven and a standard deviation of three species. There was no apparent relationship between species richness and tide level or time of day. However, species richness was consistently above average in the eastern half of the plot and equal to or below average in the western half of the plot. The R^2 value for the correlation line was 0.688 (Figure 1). In congruence with other studies (Lynch 1995), we found that species accumulation began to level off rapidly at all of the points. On average, 73.3% of species had been observed after 15 minutes, 89.5% after 30 minutes, and 97.3% after 45 minutes.

Relative Abundances, Diversity, and Distribution—The value for Shannon's D varied from 0.455 to 0.851, with an average value of 0.653 ± 0.136 points. There was no statistical relationship between diversity and tide level, time of day, or point location. The average frequency of occurrence was 3.8 points, and it ranged from one plot to ten. The European Starling had by far the highest average abundance, exceeding the second-most abundant species—the Barn Swallow—by 358.6 percent. However, the European Starling also had the highest standard deviation, at 41.1 individuals, and the abundance ranged from zero individuals to 125. The most frequently occurring species (Figure 4) (occurrence rate>50%) were Barn Swallow (10 points), Savannah Sparrow (10 points), Cliff Swallow (9 points), Red-winged Blackbird (8 points), European Starling (6 points), Violet-green Swallow (6 points), Tree Swallow (6 points), and Killdeer (5 points).

DISCUSSION

Variability—The restored estuary at the Nisqually River Delta exhibits a high degree of temporal and spatial variability. This variation must be evaluated in order to design a protocol for monitoring that will result in data that is representative of the site in question. Spatial distribution of birds using the site is the result of patterns of habitat complexity, features of individual species, predator-prey interactions, and competition (Livingston 1987). It has also been shown that shorebird species show temporal patterns of foraging activity with respect to tidal fluctuations (Burger et al 1977).

The detectability of a song bird may be related to how frequently it sings (Farnsworth et al. 2002). We recorded more Savannah Sparrows than Killdeer or Spotted Sandpipers. All are relatively inconspicuous, but Savannah Sparrows sing more frequently.

This disparity in species richness can be attributed to two factors: timing and methodology. We began visiting the site just prior to spring migration and visited the site regularly throughout migration. The survey period occurred at the tail end of migration. As such, we detected many species during the reconnaissance time that would not be present during the survey time (i.e. *Calidris* Sandpipers, American Wigeon, etc.). Also, during the reconnaissance time, our activities involved walking around the site, so observed a broader range of species than could be observed in a fixed location. During the survey period, we observed only a small fraction of the species that could be expected to occupy the site at a larger temporal and spatial scale.

The duration of monitoring a restoration site after it has been altered is another factor to consider. Restoration of a coastal wetland or saltmarsh requires 15 to 20 years, possibly longer, to develop into a wetland whose function replaces that of which was lost (Mitsch and Wilson 1996). A regular interval of monitoring efforts over a long period of time would give a insight as to how bird species abundance and use of the site changes as the function of the restoration area evolves over time.

With these aspects of the site in mind, a sample design was created. Several different methods were tested on the area to see what worked and what didn't. A complete census of birds present in the area was not a possibility. First of all, no vantage point from which to take this census was present on the site. The site's size also proves problematic as well as the presence of tall grass throughout the restoration zone.

We also tried a variable radius point count method. Estimating distance from the observer to the bird sighted is difficult to do. The area was too flat to use a rangefinder and placement of flags at varying distances created too much disturbance. It would also decrease the number of plots that could be sampled simultaneously.

Although a fixed radius plot is normally used for territorial birds, we felt that it would be the most effective type of sample design.

Some of the obstacles encountered during the sampling period included decreased visibility due to the height of the grass, tidal inundation at 13 feet, and difficulty of walking through the site. Some suggestions to remedy these difficulties are to conduct sampling when the vegetation height is not an issue, coordinate sampling times with tide levels according to the location of the plots, and use semicircular plots based on the road instead of traveling into the marsh. A large group of volunteers walking on the marsh could prove detrimental to ground nesting and grass nesting birds in the spring. Each plot should also have at least two people for recording and observing. This is also helpful when the two people have different bird identification skill sets.

Different observers have different capabilities, and they need to be trained accordingly (Dobkin and Rich 1998, Farnsworth et al. 2002).

The assumption is that we're seeing a certain fraction of all birds (Thompson 2002). The problem is that detection probability is spatially and temporally variable.

What do the results mean?
Further studies needed.

Why is it useful?
Provides a "snapshot" of the site the spring after it was restored
Starts a working species list for the site
Gives future studies baseline data to compare their results with
Difficulty of designing a sampling protocol.
Varying habitats mixed in together – marsh, grassland and mud flat
Point counts for territorial birds and limited visibility
Complete census for shorebirds
Area has both
Suggestions for future studies involving volunteers

Don't walk into the marsh. It is difficult, becomes inundated and you risk stepping on nests or potentially disturbing other research sites.

Limit sampling when grass is tall - late spring, summer. Visibility is greatly hindered at this time and counts become less accurate.

Use the road as a transect for systematic random sampling plot placement. i.e. semicircular plots extending into the marsh. (curious to see if results from this type of study design compare to results of current study)

1	Great Blue Heron	*Ardea herodias*	28	Glaucous-winged Gull	*Larus glaucescens*
2	Greater White-fronted Goose	*Anser albifrons*	29	Caspian Tern	*Sterna caspia*
3	Canada Goose	*Branta canadensis*	30	Rufous Hummingbird	*Selasophorus rufus*
4	Wood Duck	*Aix sponsa*	31	Western Wood-Peewee	*Contopus sordidulus*
5	Mallard	*Anas platyrhynchos*	32	American Crow	*Corvus brachyrhynchos*
6	American Wigeon	*Anas americana*	33	Tree Swallow	*Tachycineta bicolor*
7	Cinnamon Teal	*Anas cyanoptera*	34	Violet-green Swallow	*Tachycineta thalassina*
8	American Green-winged Teal	*Anas crecca*	35	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
9	Common Merganser	*Mergus merganser*	36	Barn Swallow	*Hirundo rustica*
10	Hooded Merganser	*Lophodytes cucullatus*	37	Cliff Swallow	*Petrochelidon pyrrhonota*
11	Turkey Vulture	*Cathartes aura*	38	Black-capped Chickadee	*Poecile atricapilla*
12	Northern Harrier	*Circus cyaneus*	39	Marsh Wren	*Cistothorus palustris*
13	Red-tailed Hawk	*Buteo jamaicensis*	40	Bewick's Wren	*Thryomanes bewickii*
14	Bald Eagle	*Haliaeetus leucocephalus*	41	American Robin	*Turdus migratorius*
15	American Kestrel	*Falco sparverius*	42	Swainson's Thrush	*Catharus ustulatus*
16	Merlin	*Falco columbarius*	43	American Pipit	*Anthus rubescens*
17	Peregrine Falcon	*Falco peregrinus*	44	Cedar Waxwing	*Bombycilla cedrorum*
18	Semipalmated Plover	*Charadrius semipalmatus*	45	European Starling	*Sturnus vulgaris*
19	Killdeer	*Charadrius vociferus*	46	Yellow Warbler	*Dendroica petichia*
20	Greater Yellowlegs	*Tringa melanoleuca*	47	Yellow-rumped Warbler	*Dendroica coronata*
21	Spotted Sandpiper	*Actitis macularia*	48	Common Yellowthroat	*Geothlypis trichas*
22	Western Sandpiper	*Calidris mauri*	49	Savannah Sparrow	*Passerculus sandwichensis*
23	Least Sandpiper	*Calidris minutilla*	50	Song Sparrow	*Melospiza melodia*
24	Dowitcher sp.	*Limnodromus sp.*	51	White-crowned Sparrow	*Zonotricha leucophrys*
25	Common Snipe	*Gallinago delicata*	52	Red-winged Blackbird	*Agalaius phoeniceus*
26	Wilson's Phalarope	*Phalaropus tricolor*	53	House Finch	*Carpodacus mexicanus*
27	Red-necked Phalarope	*Phalaropus lobatus*	54	American Goldfinch	*Carduelis psaltria*

Table 1- Complete species list for the ten-week investion.

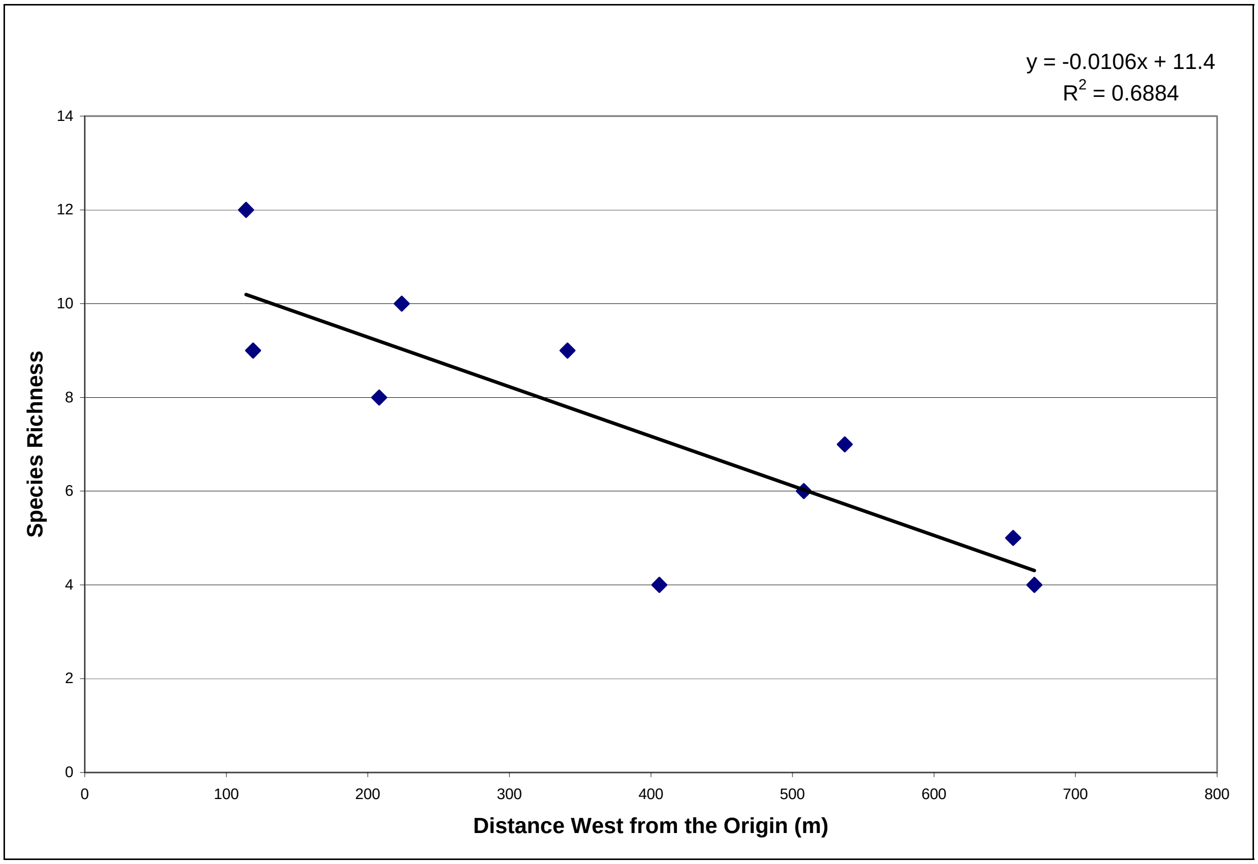

Figure 1-Correlation between point location and species richness.

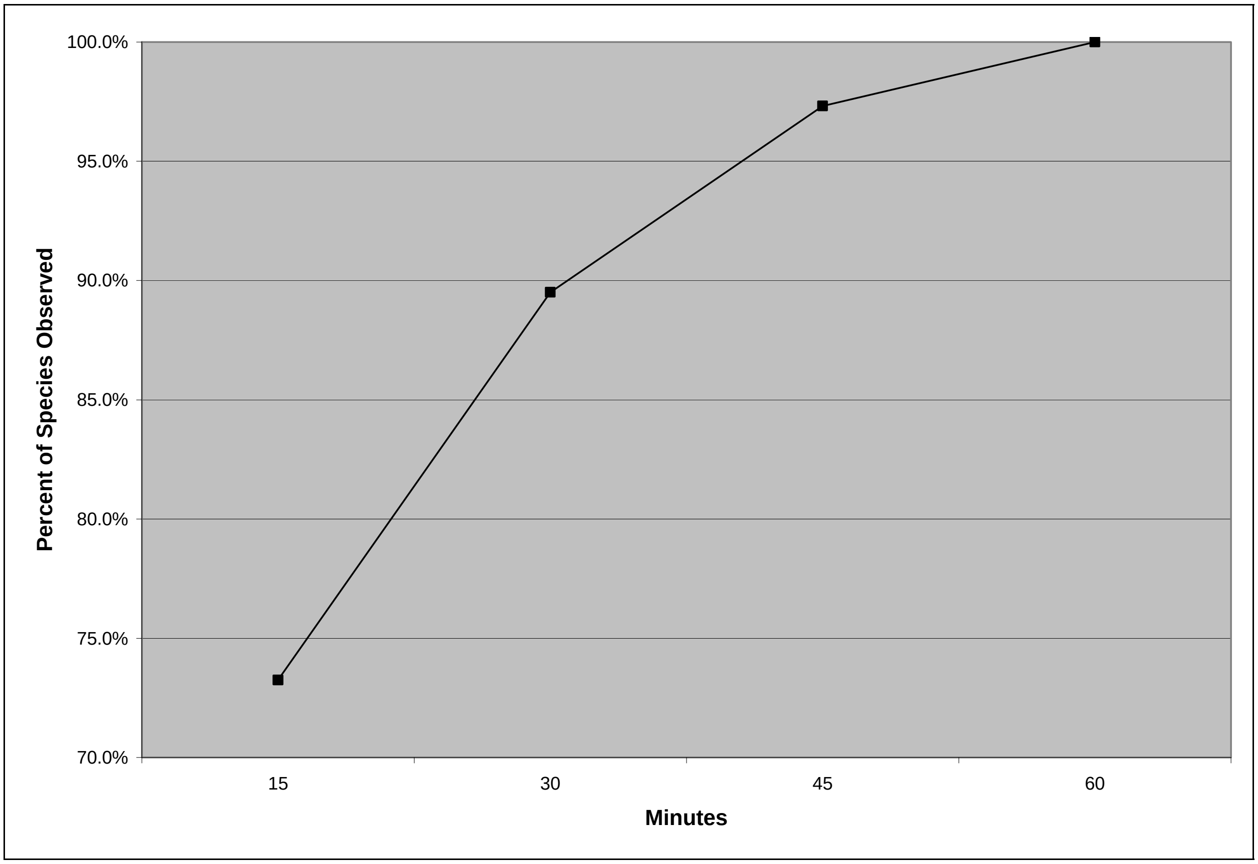

Figure 2- Average species accumulation across the one-hour survey period.

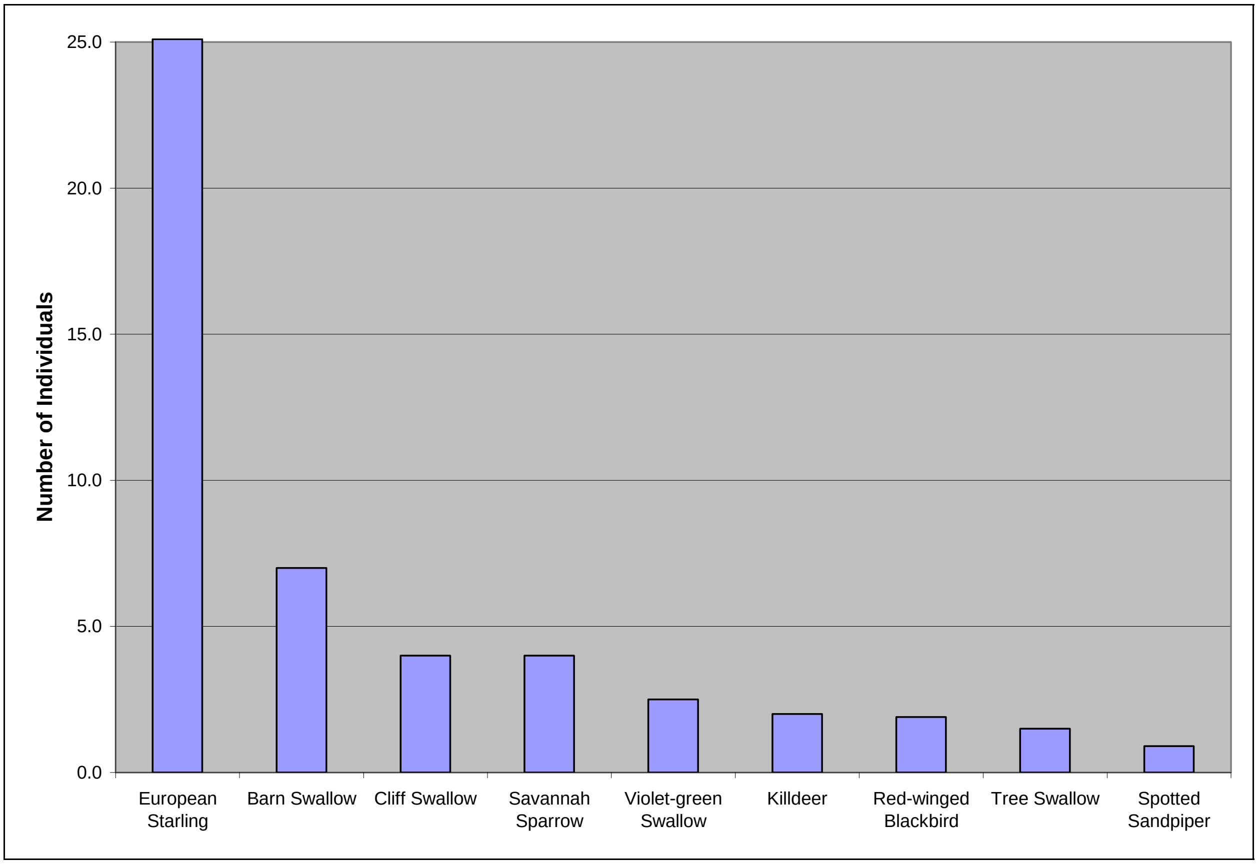

Figure 3- Average abundance of the most common species.

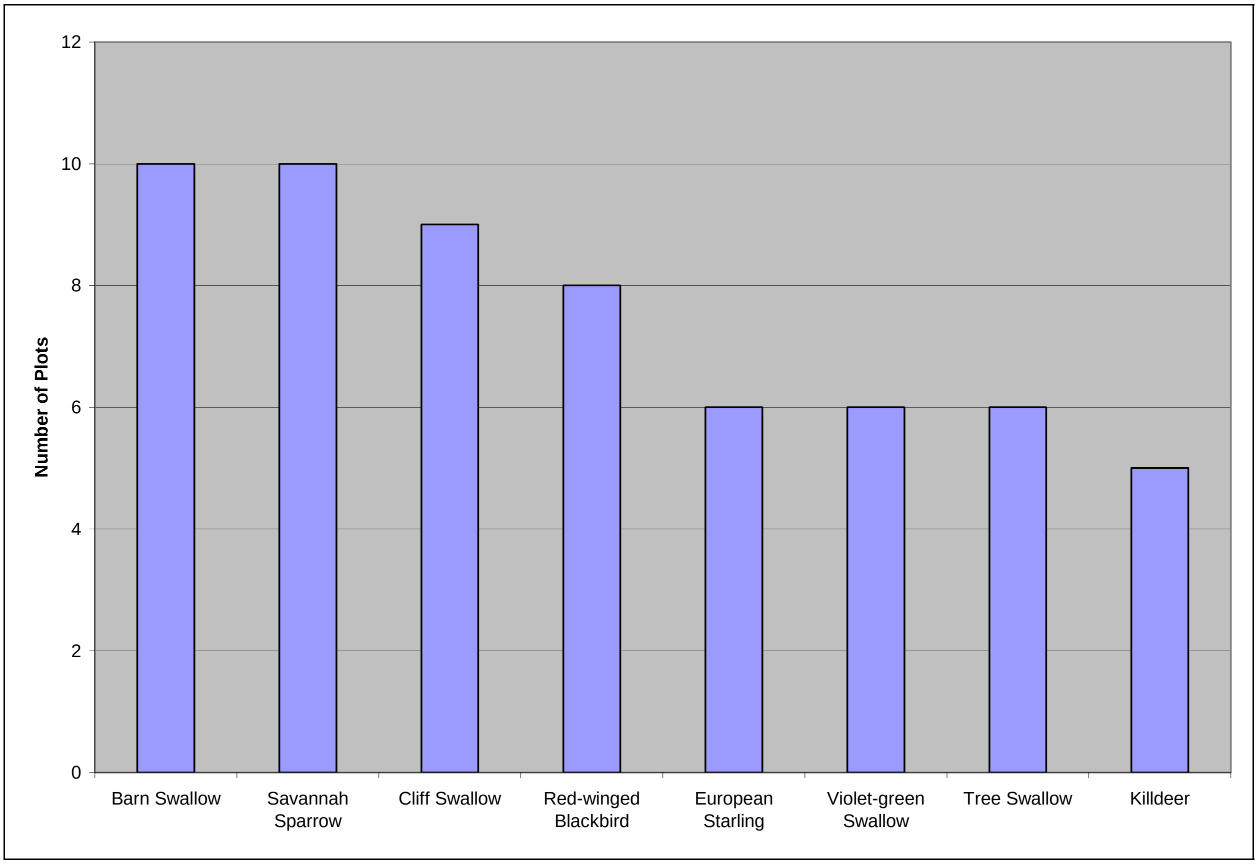

Figure 4- Frequency of occurrence of most ubiquitous species.

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